Operator Training: Booster Injection

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September 2007

Purpose

- The purpose of this training to introduce new operators to the basic features of Booster injection.

- A practical exam based on the information conveyed in this class will be given on a one-on-one basis in the upcoming weeks.

Part One: Booster Injection

- Currently, all species of particles accelerated in the AGS must first be injected, accelerated, and extracted from the AGS Booster

- Two sources from which beam is delivered to the Booster
    - LINAC
    - Tandem Van de Graff
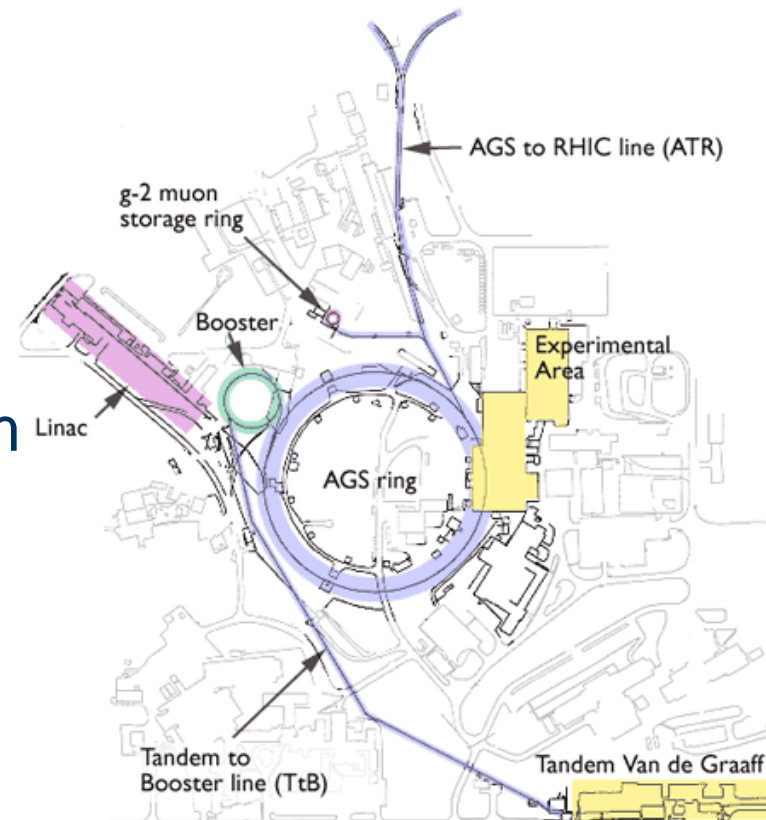
The LINAC

- Two species of particles
  - High Intensity Proton Mode
  - Polarized Proton Mode
- Transported from source to the LINAC via LEBT
  - Low Energy Beam Transport
- LINAC accelerates protons to 200 MeV
- Transported to Booster via LTB transfer line
- Utilize stripping foil at Booster injection
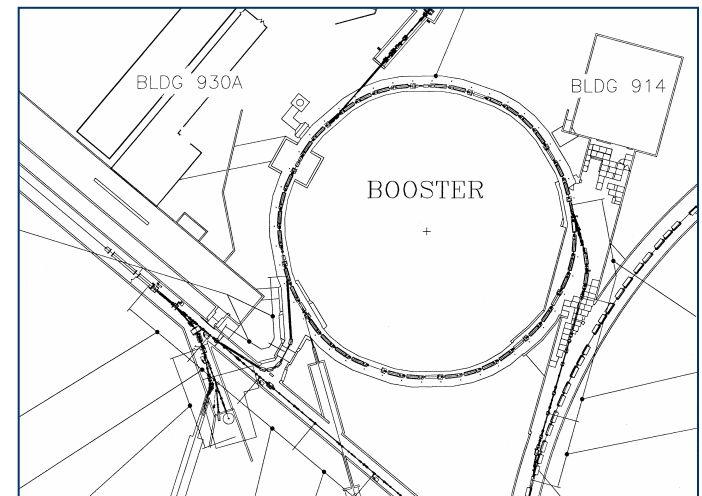
The Tandem van de Graff

- Pre-accelerates all species of ions to be injected into Booster

- Beam is transported to Booster via TTB transport line

- Stripping foil(s) in transport line are used to attain desired charge state for injection into the Booster

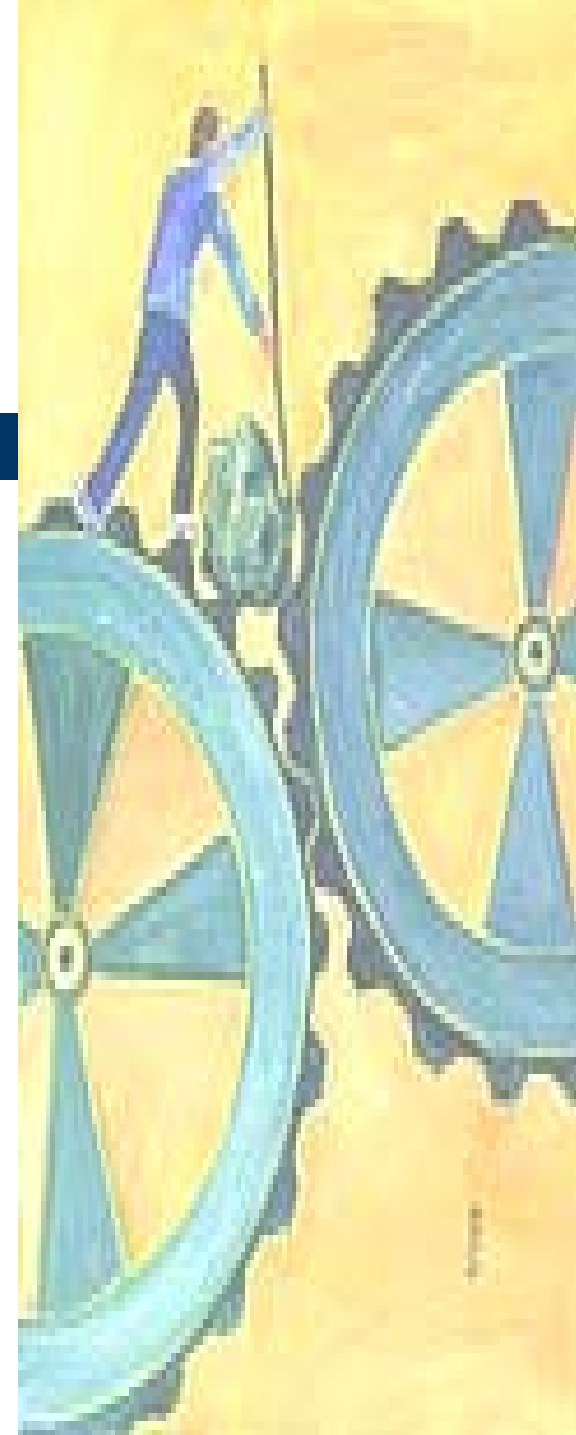- An electrostatic inflector is used to inject beam into the Booster

Potential Problems

- Problems can be broken down into several categories:
   - Source parameters
    - Timing
    - Magnetics

Symptoms

- Causes of problems can be narrowed down by proper troubleshooting
  - Checking for symptoms
 - Assessing their significance

Alarm Display

- Alarm Display (ADT) will likely show obvious problems
  - Many faults result in alarm on ADT
  - To simpify things, filter can temporarily be set to display only Booster alarms (set filter to b*)
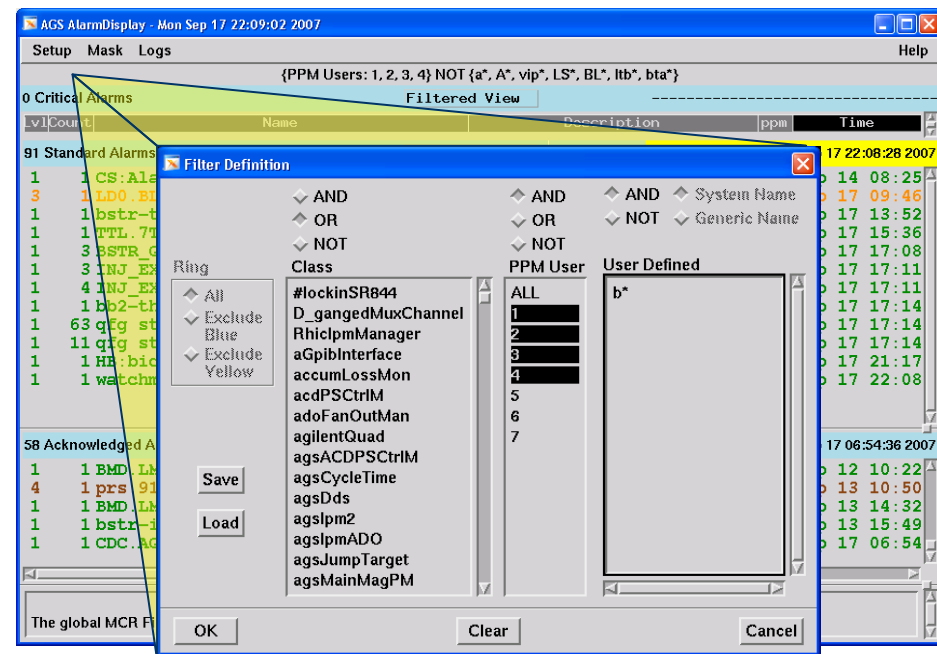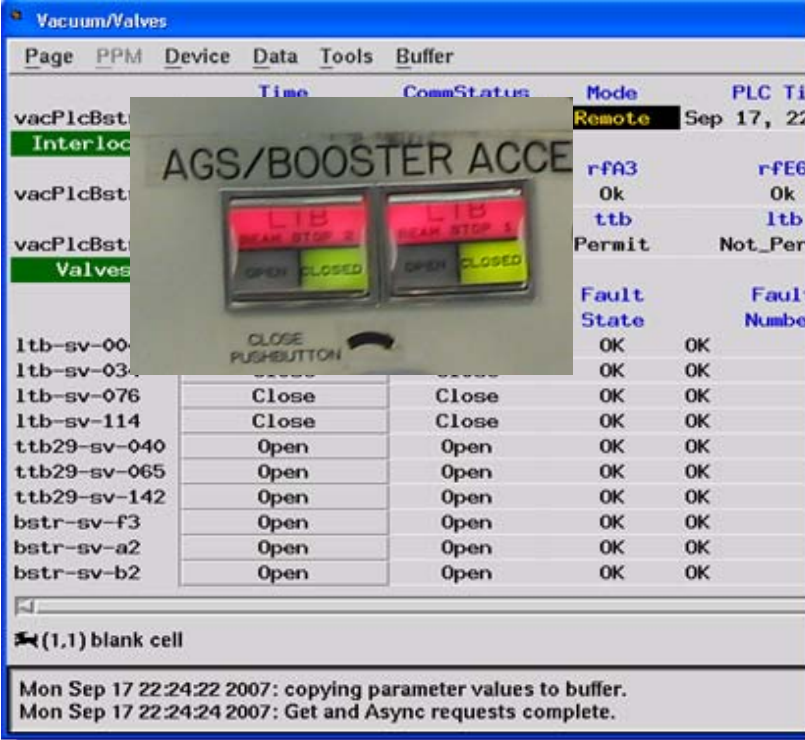
LINAC Problems

- Chirping alarm during LINAC operation could indicate problem
- Check for obvious problems
  - Beam stops closed
  - Vacuum valves in
  - Permit link not valid
  - Booster beam inhibit latched
  - Device has tripped valves
  - LEBT timing is wrong
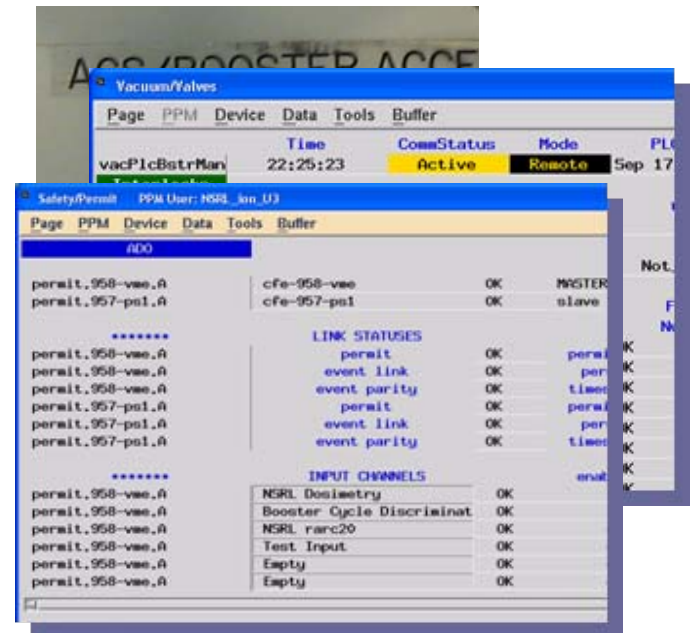
LINAC Alarms

- If LTB beam stops are closed, check for interlocks or failures
  - Clear the problem and open the beam stops
- If vacuum valves in the Booster, LTB or BTA are closed, attempt to open them
  - If they open, problem is solved
  - If they do not open, check the vacuum gauges and check the vacuum.
  - Call the vacuum group for assistance.

LINAC Alarms

- If the permit link has failed, clear the offending input channel, reset link and continue

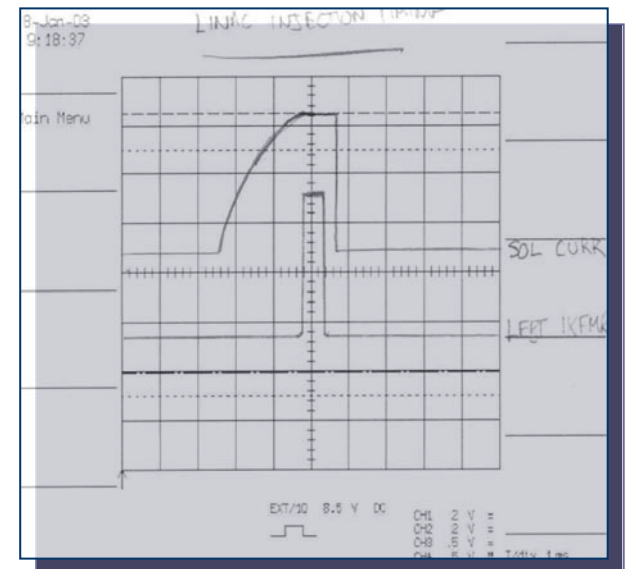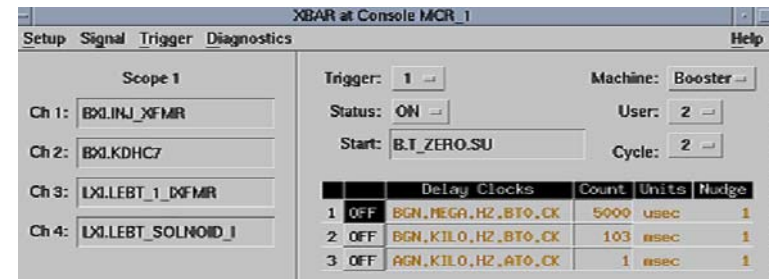- If the Booster rad inhibit has latched, reset and continue

- If the inhibit latches more that once, correct the problem, reset and continue

- Device off:
  - Check ADT
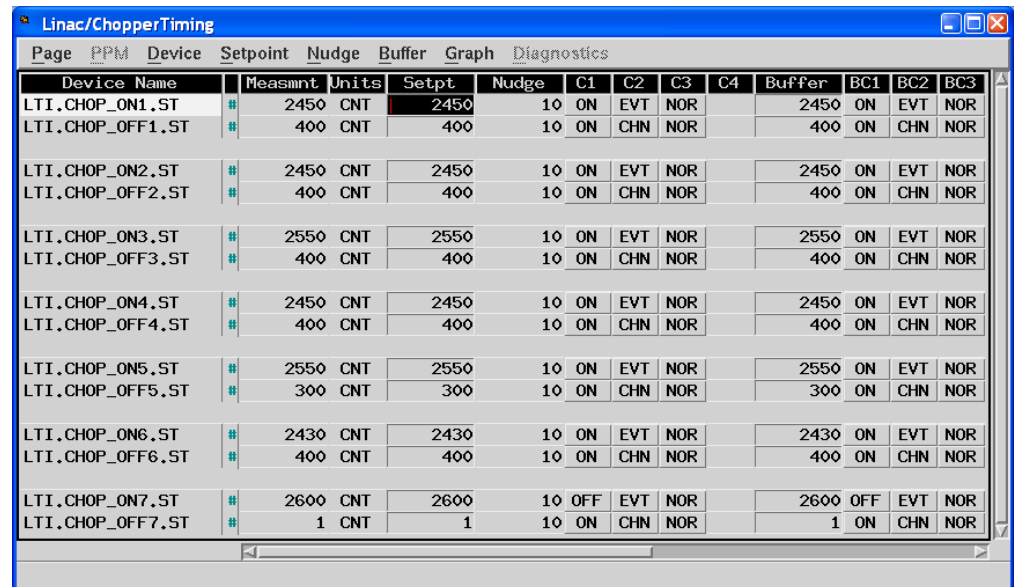 - Turn device on, continue
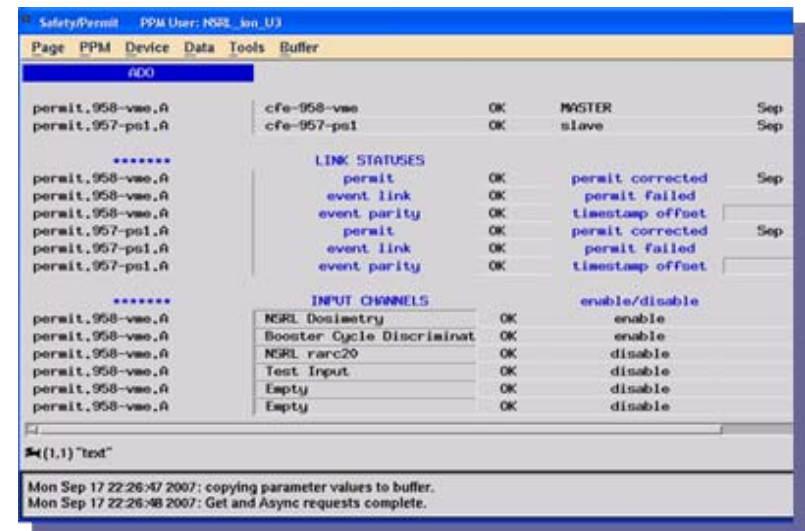
LEBT Timing

- Solenoids in the Low Energy Beam Transport (LEBT) are pulsed
  - Timing of pulse must coincide with the beam
  - Wrong timing will cause an audio chirp alarm
  - Connect the signals LEBT_1_IXFMR and LEBT_SOLENOID_I to a scope using XBAR
  - Flattop of quad pulse and beam current pulse should be aligned

LINAC Alarms and Some Beam…

- Check that none of the modules at LINAC are mispulsing
    - Camera in LCR
- Check that the Booster Loss Monitors are in LOW gain for protons, HIGH gain for heavy ions
- Check that none of the LOSS monitors in HEBT are inhibiting the beam (camera in LCR)

No LINAC Audible Alarm

- Check that the audio alarm is not acknowledged
- Check source output
  - Look at TV channel for LINAC source
- Check that the slow chopper is working and on

Ion Injection

- All species other than protons and polarized protons are pre-accelerated at the Tandem then transported to the Booster via TTB

- MCR Operations takes responsibility for the beam at section 27 of the TTB line

- Tandem Operations is responsible for areas upstream of 27

Tandem-to-Booster

- TTB magnets are controlled via pet
- Readbacks for power supplies in TTB must be within tight tolerances or they will generate an alarm
- A potential problem arises when the 'SCAN' control is off for a particular section of TTB
  - When scan is off, there is no communication between controls and power supplies.
  - If a supply was adjusted with scan off, it may generate a false alarm.

Troubleshooting TTB Injection

- No Beam:
  - Check the obvious.
    - Are there reasonable Booster Input numbers?
  - Get records of good running conditions
    - E-logs
    - End-of-day documentation
  - Look for beam in TTB
    - Current transformers
    - Harps
    - Cups
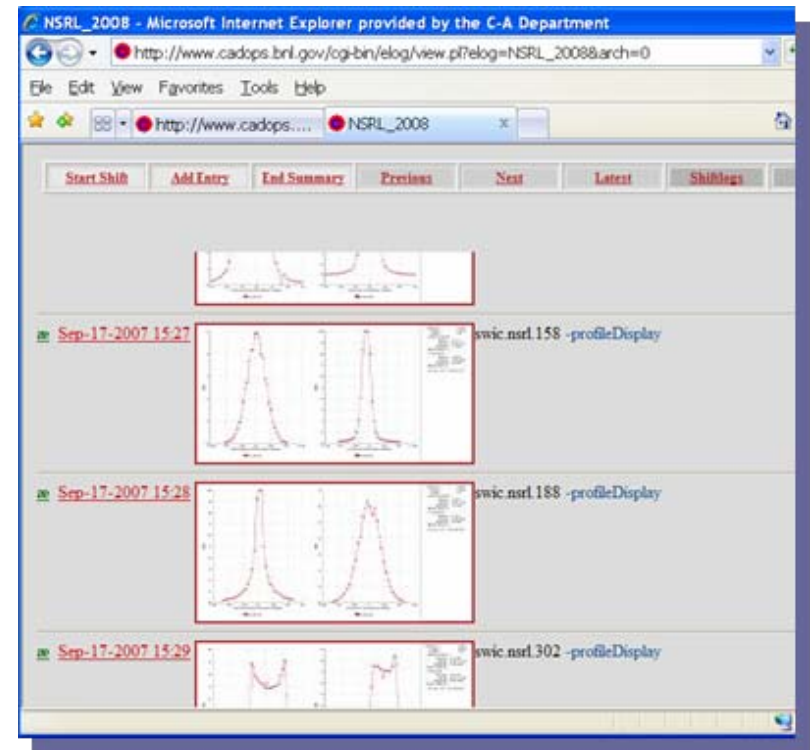
No Ion Beam

- If there is no beam observed in section 27, call Tandem Operations
- If beam is observed past in section 27, check:
  - Intensities with current transformers
  - Positions and shapes with harps – compare to known good values

Intermittent or Little Beam in Booster

- Check that the beam is getting to the Booster
  - Check the LTB harps and Transformers.
- Booster input stable?
  - If no, check the source output
  - If the amplitude or width is unstable, the source will need adjustment

No Circulation in Booster

- Turn the RF off
- Are injection bumps working properly?
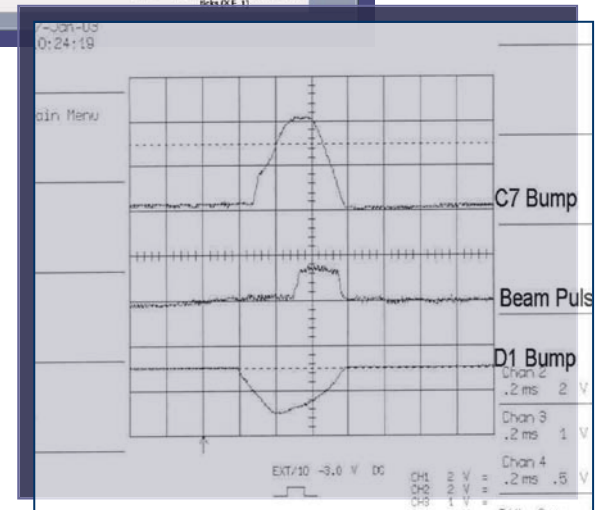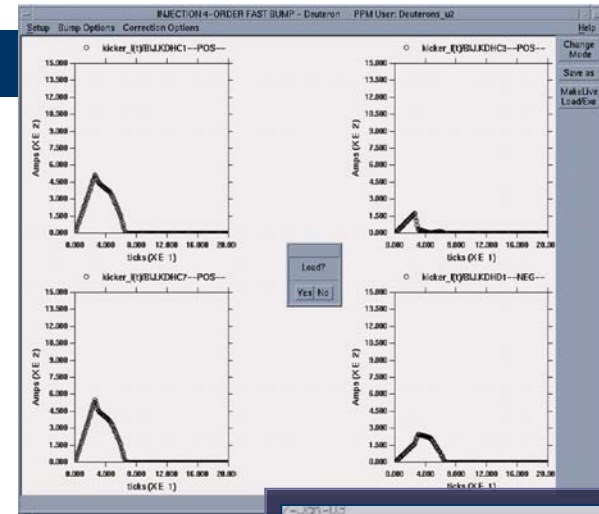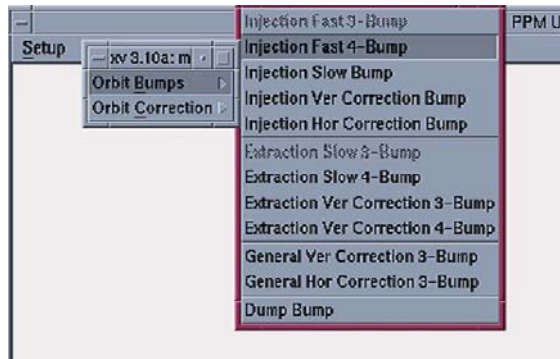
Charge State

- If adjusting inflector is the only means of producing poorly circulating beam perhaps charge state is incorrect
    - Contact Tandem Controls

No Injection Transformer Signal

- Check Dwell Field.
  - In Configure:
    - Select '*Timing/Booster/Auto Calibrate Read Backs*'
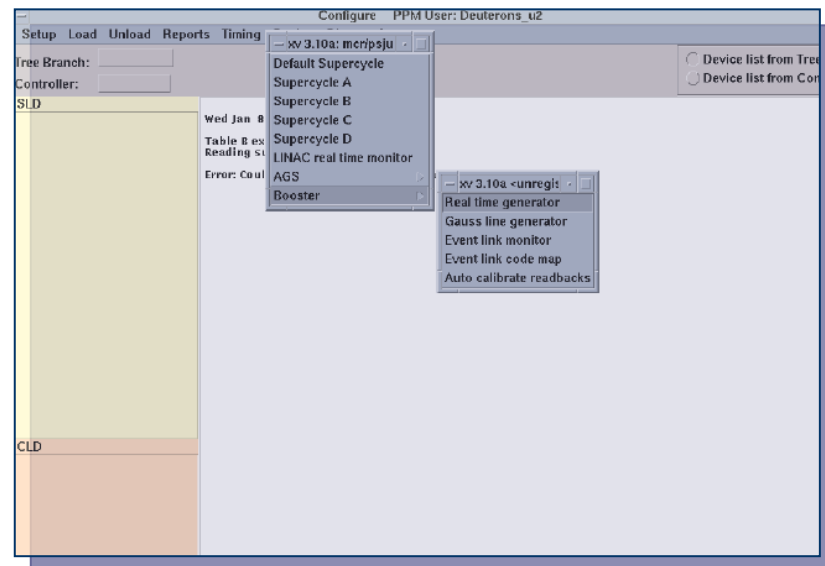
Check High-Field Magnets
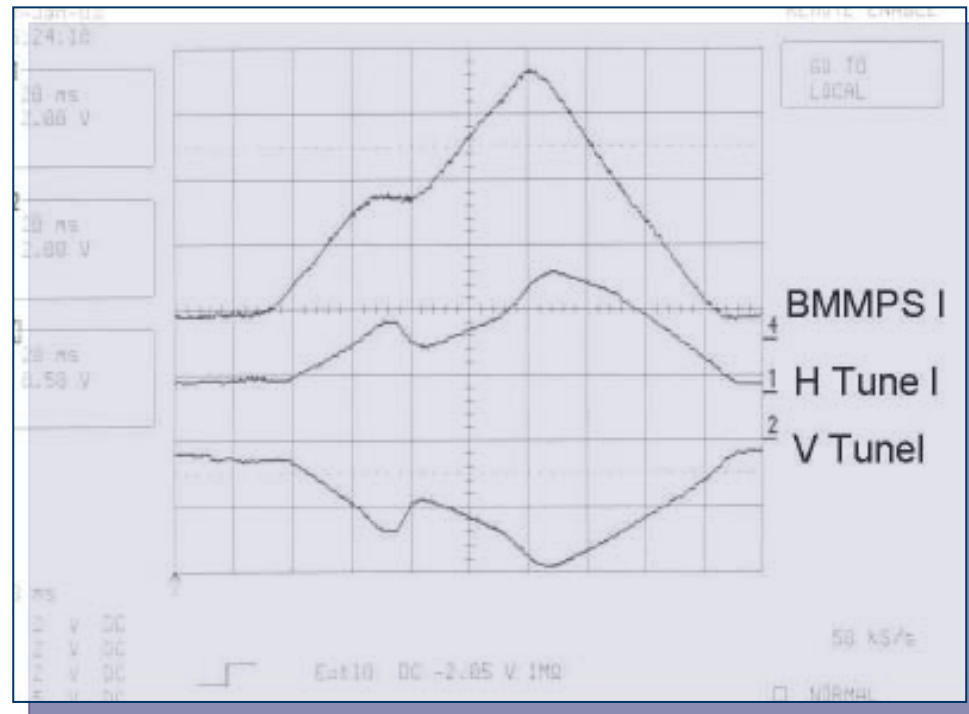
Tune Control
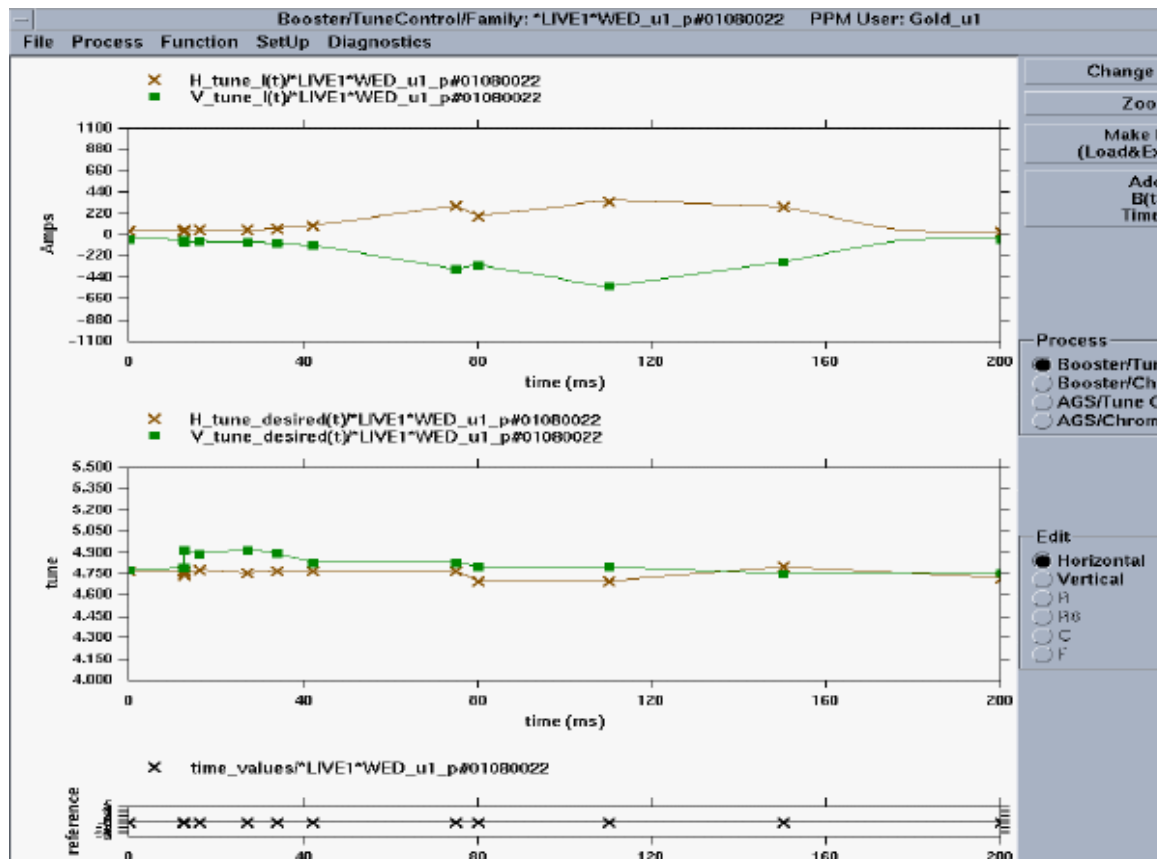
Vertical Tune

- Often when running high intensity protons, Booster is set up such that the vertical tune is very close to 5, an integer resonance capable of causing rapid beam loss

- Lowering the tune by .05 units will allow beam survival

- The tune can then be optimized after beam is re-established

Bump Timing

- Injection bumps and beam pulse must be properly aligned to allow injection.
- The following illustrates proper timing for heavy ion operation
- Note that the beam pulse is aligned with the collapsing edge of the bump

Injection Bump
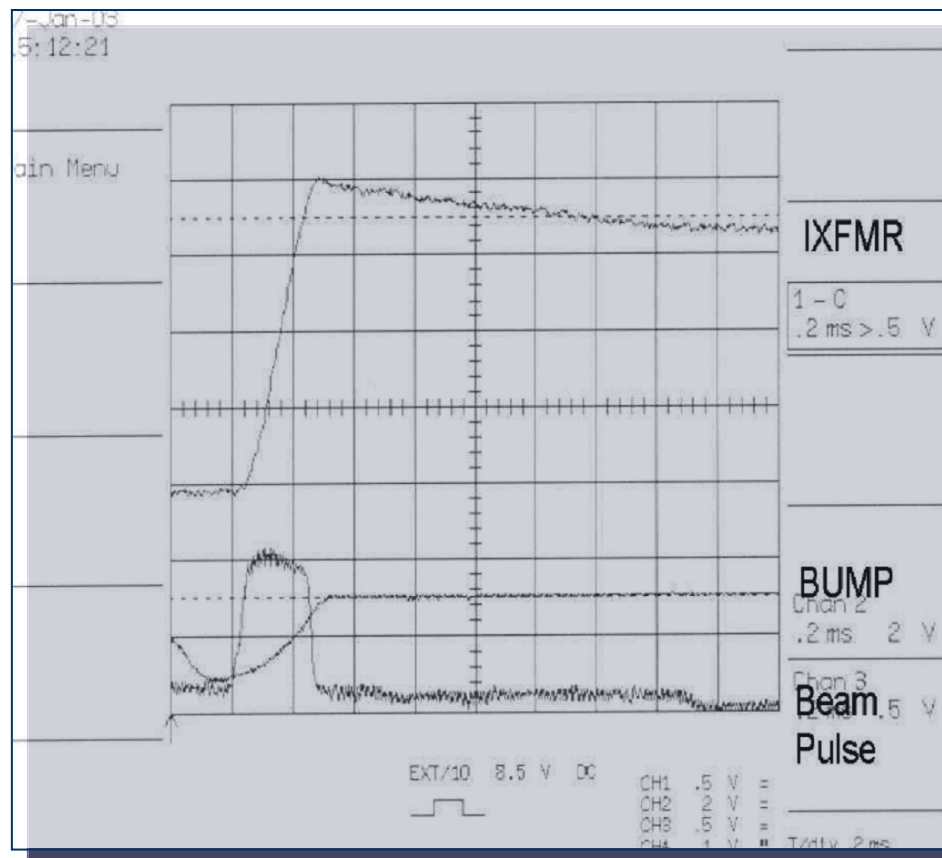
Other Possible Interruptions

- Check correctors
- Check dump bump
- Check that extraction equipment is not on during injection
- Is the foil in? (yes for protons, no for ions)

Conclusions

- Injection into the Booster in the first stage of acceleration critical to MCR operations
- Problems can usually be found and corrected when a structured approach is used in deciphering symptoms
- Subtleties in injection are learned over time and with experience…

Troubleshooting Checklist

Symptom	Possible Problem	Method for Finding	Solution
No beam in transport line.	Tripped or maladjusted element.	Check for alarm on ADT. Look in pet.	Turn on or send correct value to element. Ensure beamstops are opened.
No beam in transport line.	No source output	Use TV to look at LINAC source. Contact Tandem personnel to inquire about Tandem source.	Tune source to regain normal output.
No beam in transport line.	Obstruction in line.	Check ADT for Vacuum alarms. Check pet for cups/foils/harps	Correct any vacuum problems and open valves. Put cups/harps/foils to proper positions.
No beam in transport line.	LEBT timing problem.	Look at scope in LCR for beam pulse vs. solenoid pulse timing.	Move timing parameters to get solenoid pulse and beam aligned.

Troubleshooting (Continued)

Symptom	Possible Problem	Method for Finding	Solution
Beam in Transport, not Booster.	Injection foil in/out	Check pet	Put foil in proper position (in for protons, out for ions).
Beam in Transport, not Booster.	Injection bumps malfunctioning/miss-times	Check ADT. Set up scope to look at bumps and beam pulse.	Re-load functions/repair power supplies and adjust timing as needed.
Beam in Transport, not Booster.	High field magnets not on/Bad function	Check ADT. Look at expected functions (applications) and analog signals (scope).	Repair faults, turn on and load proper functions.
Beam in Transport, not Booster.	Low field supplies wrong/bad function or off.	Check ADT. Look on spreadsheet. Check analog signals.	Repair faults, turn on and load proper functions.